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VOL. XVI DECEMBER, 1929 No. 12

EDITORIAL

The holidays are here, the part of each year when naught should have place but good cheer.

Lest we forget that with the passing of all the holiday season, inventory time comes upon us within the month. We wonder if it would be amiss to check up our own good selfs as well as our wordly possessions.

During this time we no doubt shall plan our production, map out accident prevention, power generation, investigate tank leaks, pipeing the handling of other numerous problems, so essential to a successful foreman electro-plater and executive, "yet will we think to inventory ourselves?"

Have we made progress in 1929 mentally, financially and physically; how much have we learned from our associates in the A. E. S.; how much have we contributed to their success, and to the Society; have we assisted the branch officers and have they checked up to see how much assistance, if any, they have contributed to the president and national officers; what plans have we made to assist Baltimore-Washington Branch to make a success of our 1930 Annual Meeting, if any; how many practical plater papers will you present at next annual and just how many will be there to enjoy a convention in such a historical place as the Capitol of the United States? Why not make a few real private inventories as suggested, and get behind A. E. S. this year and make 1930 best year we ever had.

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PROGRESS REPORT

"The Protective Value of Chromium Plating"

By W. P. Barrows, Research Associate of the American Electroplaters' Society at the Bureau of Standards

I—Introduction

At a recent meeting of the Research Committee of the American Electroplaters' Society, it was decided that the principal subject for their research should be the protective value of chromium plating. Since that time the general scope of the problem has been outlined, and progress has been made upon the first phase of the investigation.

The entire research will include:

1. A study of methods of measuring the porosity of chromium coatings.

2. The effects upon the porosity caused by different conditions used in the chromium plating, by the thickness of the chromium, and by the use of one or more layers of other metals such as nickel and copper prior to the chromium coating.

3. Accelerated corrosion tests such as may be conducted in the laboratory in short periods.

4. Atmospheric exposure tests. Some of these will be made in the locations used by the American Society for Testing Materials in their tests now in progress on coated metals. Tests will be made upon iron and steel, and upon the non-ferrous metals, including copper, zinc, brass and aluminum.

Thus far the research has been confined to the first of these problems, to which this progress report is devoted. It should be emphasized that no final conclusions or recommendations regarding the porosity or protective value of chromium coatings are warranted from the following results, which refer simply to methods of testing.

II—Methods of Detecting Porosity

The results of experience and of published researches show that chromium coatings with the commonly used thickness are porous, and that the chromium does not exert any protective value such as zinc does on steel against the corrosion of the base metal exposed through pores. It is obvious, therefore, that any improvement in the quality of chromium plated products must depend upon a reduction of the porosity of the chromium or of the intermediate coating applied between the base metal and the chromium. In order to determine whether such an improvement is effected by any given procedure, it is necessary to have reliable methods for detecting the porosity and evaluating its extent. The following methods were investigated:

1. With Chemical Reagents. The most generally used method of detecting porosity in a metal coating is to treat the surface with some reagent which will have little or no effect upon the coating, but will attack the base metal that may be exposed through the pores and will give some visual evidence of the attack at those points.

(a) *On Iron.* (1) *Ferroxyl Test.* The most common example of such a test is the well-known ferroxyl test, which has been applied in various forms to detect porosity of coatings of metals such as copper, lead, tin and nickel on iron and steel. The reagent contains some corrosive compound, usually sodium chloride, to attack the iron, and a ferricyanide to produce a blue color with the ferrous salt thus formed. The test is not applicable to coatings of zinc and cadmium, which are attacked by sodium chloride more readily than is iron. As chromium is usually "passive," i.e., is more noble than the iron, the test can be used to detect porosity of chromium coatings upon iron or steel. It was found that a solution containing merely 10 g/L of

sodium chloride and 1 g/L of potassium ferricyanide yielded in 30 minutes more sharply defined blue spots or lines than when agar, commonly used in this reagent, was present.

(2) *Copper Immersion Test.* When a piece of ordinary iron or steel is introduced into an acidified copper sulphate solution, copper is deposited upon it by "immersion," i.e., the iron passes into solution and replaces the copper. It was found that this test can be used to detect porosity in chromium coatings applied directly to steel. When the chromium plated piece is immersed in an acidified solution of copper sulphate, sharply defined red spots and lines are produced within 30 minutes wherever there are pores in the chromium.

(b) *On Copper and Brass.* It has been shown by various authors that the ferroxyl reagent produces red spots where copper is exposed. As, however, the red color is due to the formation of cupric ferrocyanide, it is more logical to use a ferrocyanide than to depend on the reduction of ferricyanide. Dilute nitric acid acts rapidly on copper, but does not attack chromium. A reagent was therefore prepared consisting of 1 part by volume of concentrated nitric acid and 9 parts of water, and 2 g/L of potassium ferrocyanide. In this concentration of nitric acid there is very little oxidation of the ferrocyanide. This reagent produces sharply defined red spots or lines within 15 minutes wherever copper or brass is exposed.

(c) *On Nickel.* It was not found possible to develop any reagent which will attack nickel rapidly and not affect chromium. A solution containing equal volumes of concentrated ammonium hydroxide and water and 2 g/L of dimethyl glyoxime slowly produces pink spots or lines on chromium plated nickel wherever the nickel is exposed. As, however, it requires from 12 to 24 hours for the color to appear, the method is not satisfactory for inspection. Pending the development of a more satisfactory reagent, this procedure was used by us for comparison with the copper deposition method.

By Copper Deposition. It was found independently by Duopernell and by Kryopolous that copper does not readily deposit from an acid sulphate solution upon chromium. This fact was used by Baker and Pinner and by Baker and Rente as the basis of a test for the porosity of chromium coatings. They found that when a chromium plated surface is made the cathode in an acid copper solution, copper deposits only upon those points

where there are pores or cracks in the chromium. This method was used by the above authors for determining the relative porosity of chromium coatings produced under different conditions.

It was found in our experiments that copper can be deposited upon a piece of electrolytic chromium, but that a higher voltage is required to do so than to deposit copper on other metals. In order to insure that the copper is deposited only upon exposed base metal and not upon the chromium, it is preferable to control the applied voltage in the copper deposition, rather than the current density as was done by the above authors. At best the actual current density is indefinite, as the area upon which the copper is precipitated is not known. It was found that sharply defined copper deposits are produced in two minutes at the pores in the chromium when a potential of 0.1 to 0.2 volt is applied between a copper anode and a chromium plated cathode 5 cm (2 in.) apart, in a solution containing approximately 200 g/L of copper sulphate and 75 g/L of sulphuric acid. In subsequent tests a potential of 0.2 volt was applied under the above conditions.

That the copper is actually deposited on the base metal and not on the chromium, was shown by subsequently dissolving the chromium in dilute hydrochloric acid. The deposited copper could then be seen adhering to the base metal in the original pattern.

III—Comparison of Methods

Simply in order to determine whether the above methods yield comparable results for porosity, tests were made with deposits of chromium of three thicknesses, viz.: 0.0005 mm (0.00002″); 0.001 mm (0.00004″); and 0.005 mm (0.0002″). The first two represents the range of thin deposits such as are commonly applied over nickel on automobile and plumbing fixtures; and the latter represents a relatively thick deposit such as is sometimes applied directly to brass fixtures. All deposits were made in a solution containing 250 g/L (33 oz/gal) of chromic acid and 2.5 g/L (0.33 oz/gal) of sulphuric acid, at 45° C. (113° F.). On steel and nickel a current density of 10 amp/dm² (100 amp/sq. ft.) was used, and on copper and brass a current density of 20 amp/dm² (200 amp/sq. ft.). The chromium was deposited in each case directly on the base metal. The following tests were made immediately after the chromium deposition.

Tests were made with copper deposition upon all these types

of plate; and also by the reagents above specified for each base metal. The examinations were made with a microscope, at a magnification of about 60. It was found that for each base metal and thickness of deposit, the results by the two methods of test were in close agreement. In the thinnest deposits, round pores were observed. In the slightly thicker deposits cracks appeared which, especially on copper and brass, were usually parallel to each other and perpendicular to the direction of the last polishing. In the thick deposits the cracks were in clusters, radiating from centers, and showed no perferred orientation. The tests showed clearly that the copper deposition method, when applied as above described, gives a true indication of the nature and extent of the pores and cracks in the chromium coatings. As it is applicable to all base metals, it is more generally useful than any of the other methods.

The next problem to be studied will be the effect upon the type and extent of the porosity caused by variations in the conditions of chromium deposition; by the presence of different preliminary metal coatings; and by standing for short or long periods under different conditions. In this connection efforts will be made to evaluate the relative areas of base metal exposed; and to devise methods for determining the extent to which the pores or cracks extend through the successive layers of composite coatings.

CONDITIONS THAT CAUSE CHANGES IN THE COMPOSITION OF PLATING BATHS AND POSSIBLE REMEDIES

Prof. F. C. Mathers

Before I start the paper that I had in mind giving, I brought a sample here of telurium deposition, electro-deposition of metallic telurium. I have showed this sample at other places, but I thought you would be interested in seeing some of the newer things that we are doing.

I also have a limited number of reprints, if any of you are interested in seeing anything about telurium plating. I am sure that it is not worth any practical thing at all, and I am going to pass this around and let you see it. I would be glad if you would not mark it or scratch it or drop it, because it is very brittle. (Passes around sample.)

The mere fact that I think it is of value doesn't prove anything

because twenty-three years ago I say the original chromium experiments in Cornell by Carveth and Curry, and it is only in the last two years I felt chromium amounted to anything. Ten years ago, I tried to get some of my friends in this Association interested in cadmium plating, and they told me it was no good, and I dropped it.

Next year, I intend to do some work on the electro-deposition of bismuth. Again, I feel it is of no value, but I hope to have some interesting things to show you at another meeting.

* * * * * *

The real reason for many of the troubles with plating baths is the change in concentration or composition that takes place during operation. The ideal baths should remain absolutely unchanged in composition and concentration. Since changes do take place, the baths should be discarded and fresh ones prepared whenever the resulting deposits become unsatisfactory due to change in composition. This cannot be done on account of the cost. However, photographs do this very thing. They make up fresh developing and fixing solutions as soon as deterioration or change causes poor results.

Theoretically, a plating bath with a soluble anode should remain absolutely constant in composition and concentration. This follows from Faraday's Law. Electrolysis should do nothing except dissolve the same weight of the same metal from the anode as is deposited upon the cathode. The other constituents should not change either. However, in practice many factors tend to change this ideal and cause the baths to become richer or poorer in metal or in acid or in some other constituents.

Faraday's Law holds, but a better statement of it is that the sum of all the reactions by the current at the cathode is equivalent to the sum of all the reactions by the current at the anode. Many reactions may be produced by the current at the cathode besides deposition of metal and at the anode besides solution of metal. Moreover some reactions may take place in the bath independently of the current. The air may also act upon the constituents of the bath. In a copper cyanide bath, the hydrogen evolved plus the copper deposited plus any reducing action on the bath at the cathode are equivalent to the copper dissolved plus the oxygen evolved plus the oxidation of the cyanide at the anode. This plainly shows the difficulty of maintaining a constant composition.

There is always the chance that the side reactions at the anode and at the cathode will equal each other. If so, the metal efficiencies at the anode and at the cathode will be equal. Then no change in metal concentration of the bath will result. This perhaps comes nearest happening with nickel where the resulting metal efficiencies at the two electrodes are about equally low.

It is possible to control or at least to lessen some of these undesirable side reactions and thereby more closely approach the ideal condition of constant composition of the baths. It is the purpose of this paper to enumerate and to discuss the reactions that tend to cause variations in compositions and to give methods of lessening some of the changes.

Of course there is always a loss of solution by evaporation. The addition of water perfectly corrects for this. There is also a loss of solution by "carry out," by "throw out" and by leakage. Such losses can be completely compensated by the addition of more of the original bath. This paper does not consider the simple changes like the above.

Reactions at the Anode

I—The Anodes Dissolve Less Than Required by Faraday's Law

1. The anodes are completely insoluble.

Platinum, carbon, graphite, duriron, silicon-copper, or other silicon alloys in acid solutions, lead in sulphuric or chromic acid, iron in chromic acid and iron, nickel and cobalt in cyanide or alkaline baths, are examples. The metal concentration of any plating bath will decrease rapidly if an insoluble anode is used.

Chromium and platinum are the best examples of plating baths which use insoluble anodes. In such baths, the metal concentration must be maintained by regular additions of soluble salts; otherwise the metal concentration soon reaches almost zero. Oxides, carbonates, and the metals themselves are the only replenishing agents which will not change the composition of the baths. If any other compound is used, the acid radical of the compound will accumulate in the bath. The replenishing agent in platinum baths is platinum chloride and chlorides accumulate.

In the chromium bath there can be no accumulation of an acid radical because an oxide, "chromic acid" is the replenishing agent. When the chromium bath reaches equilibrium, all of the oxygen introduced in the chromic acid is evolved at the anode. Therefore there is no accumulation of impurities if the chromic acid

is pure. If chromium sulphate or chromium chloride was the replenishing agent, sulphuric or hydrochloric acid would accumulate in the bath as rapidly as metal was deposited. The bath would rapidly be spoiled.

This free acid which is produced when insoluble anodes are used often interferes with the deposition of the metal. If the accumulation of impurities is not acid or if the acid formed is neutralized, good plating conditions may not be much disturbed.

Examples of maintenance of baths by adding the metal are uncommon. Cowper-Coles once advocated the deposition of zinc from zinc sulphate, using a lead anode. The bath was regenerated by circulating it through a tank containing metallic zinc.

Complete deposition is often the thing desired when insoluble anodes are used. Examples are copper-silicon or lead anodes in the electro-recovery of copper from its solution and lead anodes in the recovery of zinc in hydrometallurgy.

2. The anodes are somewhat less soluble than theory.

Anodes vary greatly in their solubility. Also insolubility is likely to increase as the anodes are consumed. Indications that the anodes are dissolving less than theory are the evolution of a gas at the anodes or the formation of a film on the anodes, or the increase in voltage required to maintain the current, or the increase in acidity in neutral or acid baths. Some causes of partial insolubility of the anodes are:

a. The anodes become "passive."

Some metals in certain solutions or after certain treatments are inactive or insoluble although normally they dissolve readily. Iron can be made passive by dipping in very strong oxidizing agents such as nitric acid. Rolled nickel or nickel from electrolytic nickel cathodes may become passive in sulphate baths. Passive state is a surface phenomenon which is influenced by purity as well as by heat or mechanical treatment of the anode metal. Dipping the metal in hot hydrochloric acid removes the passive state. Perhaps the best way to combat the passive state is by adding chloride or other radical that will destroy or prevent it. The passive condition causes the evolution of oxygen accompanied by increase in resistance or voltage. Such anodes may become completely insoluble. Reduced solubility causes a reduction in the metal concentration of the bath and an increase in acidity. For example in a nickel bath where the anode solution is less than the cathode deposition, nickel sulphate must be added. Then ammonium hydroxide

must be added to neutralize the acid formed at the anode. This gives an accumulation of ammonium sulphate which makes no trouble. If nickel carbonate was used in place of the ammonium hydroxide there would be no change in concentration or composition of the bath. It must be remembered that mechanical losses from the bath constantly remove impurities such as the ammonium sulphate just mentioned. This discussion concerning the accumulation of impurities will apply in every place where replenishing is necessary.

b. A film or an insoluble salt forms on the anodes and reduces their solubility.

This is a common condition encountered in plating baths. There are several causes of this.

1. The metallic compound formed by the current at the anode may not dissolve readily. A good example of this is the copper cyanide bath. The anodes finally become coated with a film. This is directly caused by insufficient free cyanide to dissolve the cuprous cyanide that is formed at the anode by the electrolysis. There are several things that reduce the concentration of the cyanide.

A. Some cyanide is lost due to oxidation at the anode and to decomposition by the heat. These changes cannot be avoided. Although a lower temperature lessens the above losses, a low temperature cannot be used due to cathode troubles.

B. The anode corrosion is greater than the cathode deposition. Therefore the metal concentration of the bath increases and the cyanide or dissolving agent decreases. This condition is discussed later under cathode reactions.

c. Too high a concentration of some constituent or acid in the bath makes the compound formed by the current at the anode insoluble.

Too much sulphuric acid in the stannous sulphate baths reduces the solubility of stannous sulphate to such an extent that solid crystals of it may cover the anodes and insulate them. If too much sulphuric acid is present in the copper sulphate bath, solid crystals of copper sulphate form over the anode and produce an insulating film. The remedy is to remove part of the bath and add water to the remainder.

d. The anodes may be too small in proportion to the current or voltage used.

Undersized anodes will often evolve gas and become covered with an insulating cover. The area of the anodes must be regulated according to the composition of the bath and to the current and voltage used. The best area of anodes for each bath has not been carefully worked out. The area should be larger the higher the current or voltage, the lower the temperature, the greater the percent of insoluble impurities in the anodes and the greater the bath is saturated with the metallic salt. In general the larger the anode area the less the trouble with too little solubility. It is good practice to keep the anode area as small as possible and still not have the solubility of the anode less than the deposition at the cathode.

e. The crystalline structure or mechanical treatment of the anodes may affect their solubility. Some rolled nickel or electrolytic nickel cathodes are less soluble than cast nickel. Annealing cast anodes often improves their solubility.

f. Impurities in the anodes may reduce their solubility.

This effect may be classed under various heads.

1. Insoluble and unattack impurities may render the anode entirely insoluble. Often small quantities of insoluble impurities greatly increase the resistance of the anodes to corrosion. The effect of silicon in iron (duriron) or in copper is to make the iron or copper practically insoluble. The greatly increased resistance given to iron by chromium for stainless steel illustrates very well this property often conferred by alloying. If such impurities are present even in small quantities the anodes finally become entirely insoluble. There is no remedy except to use pure anodes although the addition of fluorides to the bath will often overcome the effect of the silicon. Platers probably very seldom have anodes that cause trouble from this cause.

2. The impurities although unattack may remain as mud adhering to the anodes and perhaps not affect the solubility very seriously. Metals that are less active than the metal being plated can do this. The activity or the electromotive series gives the metals in their order of decreasing activity. Antimony in lead anodes in the fluosilicate bath, silver in copper, gold in silver, copper in nickel, etc., accumulate on the surface of the anodes and reduce their solubility somewhat. This effect may be due largely to reduced effective anode surface. The smaller the area of the anodes and the higher the current or voltage the sooner this reduced solubility

raises the resistance of the bath. These insoluble and unattack impurities should not change the concentration of the bath at all unless their great quantity or the peculiar type of alloy formed renders the anode insoluble under class I above.

Some of these less active metals do dissolve to a limited extent. Whenever such a less active metal does to into solution at the anode it immediately plates out upon the cathode. This produces no change in concentration of the bath. However, such a metal may have an action upon the character of the cathode deposit. An example of this is mercury in zinc anodes. The mercury is very much less active than the zinc and therefore whatever mercury dissolves from the anode plates out at once on the cathode.

3. The impurities in the anodes may combine with some constituent of the bath giving an insoluble compound that adheres to the andoes. If the impurity in the anodes combines with any constituent of the bath, the metal concentration of the bath is thereby reduced. Trouble will finally come when the metal concentration becomes too low. Again the remedy is to use pure anodes.

This slime or anode coating may reduce the effective area of the anodes, or perhaps the salt formed by the current at the surface of the active part of the anodes diffuses very slowly. Then the condition at the surface inside the pad of slime will be the same as if the bath had become saturated. Therefore crystals may separate on the anodes and rapidly produce insulation and increase in voltage. If such impure anodes are used larger areas, lower currents and higher voltages must be employed. Sometimes an acid or a salt can be added that will keep the slime porous or at a slight distance from the active anode surface. Such a non-injurious slime can often be formed by having in the bath an acid radical that gives a soluble salt with the impurity as well as one that gives an insoluble salt. It seems as if the soluble salt which is first formed at the anode is changed afterwards into the insoluble one at a little distance from the anode surface. Hence there is less insulation and less increased resistance. A good example is a tin anode containing lead. Insoluble lead sulphate which adheres tightly to the anode is formed in a stannous sulphate bath containing only sulphuric acid. This increases the resistance and finally makes electrolysis difficult. The presence of some hydrofluosilicic acid, which gives a soluble salt with lead, in some man-

ner prevents the formation of a highly resistant film. Only anodes that are quite impure will show this trouble.

It is impossible to give a general rule setting forth what impurities and what quantities of them will cause trouble. The type of alloy formed has an important effect and the type varies with different combinations of metals.

4. The impurities in the anode may combine with some constituent of the bath and go into solution. This causes a decrease in the concentration of the desired metal although the total concentration of metals remains constant. Those impurities that are more active than the metal being plated will act in this way. Copper in silver anodes, tin in lead, nickel in copper, aluminum in zinc, etc., go into solution and gradually accumulate to a definite concentration, after which they may plate out. The silver in a bath will decrease at a rate equivalent to the increase in the copper concentration. Finally the silver concentration will become so small that good deposits under normal working conditions cannot be obtained. The silver concentration may be brought back by adding sodium silver cyanide, but the concentration of the copper will keep on increasing. If the silver anode contained 2% of copper a cyanide silver bath will gain 0.07 oz. (2 gms.) of copper and lose 0.12 oz. (3.4 gms.) of silver for every 3.3 oz. (100 gms.) of anodes consumed. The reduced concentration of the desired metal finally causes trouble in most cases.

These more active impurities sometimes increase the ease of electrolytic solution of the anodes. An example is a nickel anode containing iron.

The anode impurities, after going into solution, may precipitate as a sludge. The iron in nickel anodes is different from other impurities. The iron readily dissolves since it is near nickel in the electromotive series. Part of the iron plates on the cathode with the nickel. The rest of the iron goes into the sludge thereby decreasing the nickel concentration by an equivalent amount. The sludge formation is due to oxidation. The oxygen of the air oxidizes part of the iron from the ferrous, the form in which it dissolves at the anode, to the ferric condition. The ferric salts are not stable in nearly neutral solutions, hence they partly react with the water or hydrolyzes into insoluble sulphate or borate which forms the sludge. Some ferric and the ferrous remain in solution. Iron is deposited upon the cathode in proportion depending on its

concentration in the solution. (Besides reducing the nickel concentration of the bath, the sludge also decreases the concentration of the sulphate and the borate.) The obvious remedy for all this is to use pure anodes, preferably of metal refined by electrolysis or by the carbon monoxide method.

If hydrogen peroxide is used in the nickel bath all the iron from the above goes into the sludge and the decrease in nickel concentration of the bath is faster. The addition of nickel sulphate would be necessary to maintain the nickel concentration. The presence of flurorides or citrates in the nickel bath prevent sludge because complex fluorides and citrates are stable and are not decomposed or precipitated. In such baths the metal concentration should not change greatly even if the anodes did contain iron. However, the nickel plate would show the effect of its increased iron content. After equilibrium is reached in these baths containing the fluorides or citrates about as much is deposited on the cathode as is dissolved from the anode. However, in such baths there is some increase in metal concentration. The iron dissolves from the anode in the ferrous condition and is partly oxidized in the bath. Therefore it is deposited on the cathode from both the ferrous and the ferric condition. A given current deposits or dissolves less iron in the ferric condition than in the ferrous. Therefore the metal concentration of the bath increases. Experiments with a rotating cathode in a nickel bath gave much lower efficiencies than with stationary cathodes unless pure electrolytic nickel anodes and nickel salts free from iron were used. Then both rotating and stationary cathodes gave high yields. Iron should be kept out of the baths and the very best way to do this is to use absolutely pure anodes. The use of nickel anodes containing more or less iron is one of the greatest mistakes in present plating practice.

II—The Anodes Are More Soluble Than Corresponds to Faraday's Law

The anodes are always soluble in the bath even on open circuit. In many cases this extra solubility, as in the nickel bath, is so small that it can be neglected. In some cases, though, the anodes dissolve so vigorously that hydrogen is evolved. This extra solubility of the very active metals is pronounced and troublesome. Zinc in either acid or cyanide is a good example. This extra

solubility takes place during operation of the bath as well as on open circuit. Therefore the anode efficiency is greater than 100 percent. The free cyanide and sodium hydroxide of the bath are gradually used up while the metal concentration increases. Finally the zinc cyanide formed by the current at the anode cannot dissolve as fast as formed. A white slime of this zinc cyanide forms the surface of the anodes. This film may dissolve over night or while the bath is resting, but it reforms very soon after electrolysis is resumed. Addition of more free cyanide or better cyanide and sodium hydroxide will temporarily stop the trouble. This same discussion applies to zinc sulphate, cadmium cyanide and iron baths. There are several ways of lessening this excessive solubility.

a. Anodes made of electrolytically refined zinc are less active than impure anodes. Small quantities of such metals as copper greatly increase this solubility of zinc. These impurities act with zinc to form short-circuited batteries whereby the zinc dissolves. Pure anodes of electrolytic zinc will dissolve very little on open circuit.

b. Amalgamation of the anodes very effectively reduces the excess solubility. The overvoltage of hydrogen on mercury is so high that the evolution of hydrogen is stopped. The amalgamated anodes of electrolytically refined zinc is the best remedy for excess solubility of zinc.

c. If the free acid or free cyanide and alkali is kept very low this excess solubility is also reduced. Then when anode trouble comes more of the acid or cyanide is available for adding.

d. Insoluble anodes of iron, lead, etc., the particular metal depending upon the acid radicals in the bath, can be used part of the time whereby the metal content of the bath can be reduced as much as desired. The objection to this is that undesirable oxidations may take place at this insoluble anode. Cyanide is oxidized and destroyed. Iron and tin baths would be badly oxidized. Insoluble anodes would do no harm in acid copper or zinc sulphate baths.

e. This extra solubility is directly proportional to the area of the anodes. The smaller the area the longer the time required for the trouble to develop.

f. Removal of the anodes from the bath, when not in use, avoids

part of the trouble. This is especially recommended with zinc and iron baths.

Action of Air Upon the Baths

One effect of oxidation has already been discussed under the action of iron impurities in nickel anodes. Iron and tin baths are easily oxidized by the oxygen of the air. Such oxidation causes sludge or precipitates which are undesirable. More trouble is experienced during rest periods than during operation. These oxidized salts act upon the anodes to dissolve them on open circuit. This brings about an increase in metal concentration of the bath. This action of the oxygen of the air in causing extra solution is apparent even in the case of copper although copper in the sulphate bath is not subject to oxidation. If an acid copper bath is stirred with air the anode dissolves rapidly and the acid concentration decreases at the same rate. Other metals will act in the same way.

Air contains about 0.035 percent of carbon dioxide. Every alkaline bath constantly absorbs this carbon dioxide with formation of carbonates. Also the air can change cyanides to carbonates. There is no easy way of removing the carbonates. In cyanide baths, the addition of barium or calcium cyanide will precipitate barium or calcium carbonate leaving sodium cyanide in solution. The objection to this is the cost and the trouble with the sludge produced. Carbonate can be lowered by removing the crystals that form in alkaline baths during very cold weather in cold rooms. No method has been suggested for removing carbonates from ordinary alkaline baths. It is very unlikely they do much harm. Addition of barium hydroxide or calcium hydroxide, which is less good, should precipitate barium or calcium carbonate leaving sodium hydroxide in solution.

III. Anodes often lose more weight than corresponds to Faraday's Law. Very often this loss is due to crystals or pieces of the anodes becoming detached. Such mechanical loss has no effect upon the metal concentration of the bath.

Reactions at the Cathode

I. The weight of deposit may be greater than theory.

The actual weight of metal which is deposited upon the cathode is never greater than the theory based upon Faraday's Law. Apparently excessive weights of cathodes may be due to several

causes if experimental errors are not responsible. The trouble may be due to one of the following things:

a. The cathode deposit may oxidize during drying. An excess weight equal to the oxygen which combined with the metal will be observed.

b. A basic salt or a hydroxide or floating impurities or sludge may be deposited or may become attached to the cathodes.

c. Organic addition agents or other colloids are deposited with the metal and increase the weight. Glue in lead plating, tartaric acid in silver nitrate baths are good examples.

In the very careful determination of the electrochemical equivalent of silver by the Bureau of Standards, the very slight quantity or organic material which would dissolve from filter paper, gave an excess weight to the silver deposited from a nitrate solution.

The above things do not change the metal concentration of the bath and do not need to be considered here.

II. Less metal than theory may be deposited.

This is the ordinary condition. The great difficulty of obtaining theoretical deposition is shown by the care needed in the determination of the electrochemical equivalent of silver by the Bureau of Standards.

Any gas evolved or any other side reaction at the cathode means that an equivalent weight of metal has not been deposited. Hydrogen evolution which is the principal reason for reduced metal deposition may be caused by the following:

a. Too high a current or voltage or too low a concentration of metal in the bath may be employed. Whenever there is more current or voltage on the solution than there are metal ions or metallic salt at the cathode to carry the current or to neutralize it, hydrogen generally makes up the deficiency. The obvious remedy is to reduce the current or voltage. However, increase in the concentration of the bath, stirring, circulation, or movement of the articles being plated are all effective remedies. It is generally desirable to use as high a voltage or current as possible in order to increase the output of the bath. On the other hand, baths are made as low as possible in concentration in order to reduce their costs. This author has always recommended the use of more concentrated solutions. The tendency is in that direction, as witnessed by the greatly increased concentration of nickel baths of today as compared to the old time "double salt" baths.

b. Too much free acid, cyanide, hydroxide or other dissolving agent makes the deposition of hydrogen more easy as compared with the deposition of the metal. The active metals, those coming before hydrogen in the electromotive series such as zinc, iron, nickel, cobalt or copper in cyanide are especially difficult to deposit if much free acid or cyanide is present. If the conditions for the deposition of hydrogen, i. e., excess acid or cyanide, are not kept very poor some of these metals can not be deposited at all. The efficiency of deposition of nickel is very much greater at a pH of 6 than at a pH of 5.5. Some of the very active metals, the ones occurring much before hydrogen in the electromotive series, such as aluminum, calcium, manganese, magnesium, etc., cannot be deposited under any conditions from a water solution. On the other hand, those metals occurring much beyond hydrogen in the electromotive series such as aluminum, calcium, manganese, magnesium, etc., cannot be deposited under any conditions from a water solution. On the other hand, those metals occurring much beyond hydrogen in the activity series such as copper in acid solutions, silver, mercury, lead, tin, etc., can be deposited even when much free acid is present. This follows from the fact that these metals are much easier deposited by the current than is hydrogen; therefore free acids have little effect.

The obvious remedy for preventing hydrogen deposition is to reduce those materials that tend to make the deposition of hydrogen easy.

This trouble with excess acid or cyanide or other dissolving agent will finally correct itself in many cases. The metal concentration of the bath gradually increases at the expense of the dissolving agent until finally the hydrogen available for deposition becomes so small that only metal will deposit. The metal concentration of the bath increases at the same rate that the dissolving agent decreases. Therefore metal radicals become more available whereby the cathode efficiency increases.

Zinc cyanide baths with cast iron cathodes are exceptions to the above discussion. It seems that the cast iron or improperly cleaned wrought iron or steel catalyzes the deposition of hydrogen or lowers its deposition voltage to such an extent that mostly hydrogen is deposited. No way is known of overcoming this trouble. Why nickel, cobalt, or iron cannot be deposited from cyanide solutions is not known.

In zinc metallurgy, the zinc sulphate solution must be carefully purified especially from arsenic, manganese, cobalt and iron which, even in small amounts, cause low metal and high hydrogen deposition on the cathode.

c. An increase in temperature generally increases the case of hydrogen deposition and reduces metal deposition. The dissolving agents are more active the higher the temperature.

d. The copper cyanide baths give low cathode efficiencies unless operated hot. This is unusual. In the hot solution, the complex copper cyanide compounds probably ionize more readily into available copper. A copper cyanide bath of about double the ordinary concentration and operated at 170° F. (80° C.) gives approximately 100% cathode efficiency. Most copper baths are run at a lower temperature and the cathode efficiencies are rarely 80 and often only 50% of theory. A serious objection to the higher temperature is that the rate of decomposition and volatilization of the cyanide is increased. These low cathode yields bring about rapid increase in the metal concentration of the bath. If the cathode efficiency is 90% while the anode efficiency is 100%, every ampere of current for one hour increases the quantity of copper in the bath by about 0.004 oz. (0.1 gm.) and the free cyanide will be decreased by an equivalent quantity. Finally there will be insufficient free cyanide to readily dissolve the cuprous cyanide at the anode. A film then forms on the anodes. It is thus seen that the real trouble with the copper cyanide bath is its low efficiency at the cathode. The resultant increase in the metal concentration of the bath finally causes the anode trouble. This same discussion applies to the zinc cyanide bath. In this case, any increase in temperature increases the deposition of hydrogen.

Very low currents or voltages generally give lower percentage yields than somewhat higher currents. If there is any tendency for the deposition of hydrogen in preference to the desired metal, a very low current will find sufficient hydrogen at the cathode to neutralize a more or less large share of the current. However, at higher currents, insufficient hydrogen will be at the cathode, hence metal will make up the deficiency. Therefore the current efficiency will be higher. On the other hand, if the current is made too high there will not be enough metal concentration at the cathode and bad deposits will result. The satisfactory deposition of zinc from quite strong solutions of sulphuric acid is obtained commercially by

using high currents, whereas low currents would give only hydrogen. With the less active metals such as copper in copper sulphate and sulphuric acid, too high a current gives low efficiency. There would not be sufficient metal at the cathode, hence hydrogen would make up the deficiency. However, at very low currents the copper efficiency is very low. Dissolved air might cause the low efficiency.

Iron or other metal that can be oxidized and reduced may have a peculiar action. The oxygen of the air can oxidize the ferrous formed at the anode to ferric. Then the current may deposit no metal at the cathode but merely reduce the ferric to ferrous which later will be oxidized by the air again. This cycle can continue indefinitely. As a result the cathode efficiency is lowered to the extent of such reducing action. Therefore the metal concentration of the solution is increased. It is evident that circulation of the solution will greatly increase the above described effect.

Note: The author wishes to thank Messrs. Chas. H. Proctor and George B. Hogaboom for many helpful suggestions in the final correction of this paper.

Summary

Every effort should be made to maintain constant composition of the baths. Many troubles can be avoided by keeping as constant composition as possible. This maintenance becomes easier if the causes of the changes are known. Analyses with subsequent "doctoring" is often necessary. However, many ways are available for avoiding, at least, some of the changes that take place.

1. The purest metal that can be obtained should be used for anodes.

2. If the anodes dissolve more rapidly than needed, their area should be reduced. It is best to remove excessively soluble anodes from the baths when not in use.

3. Zinc and cadmium anodes should be amalgamated.

4. The impurity, iron, should be kept out of the baths. Iron reduces current yield with subsequent increase in metal concentration.

5. Excess free acid, cyanide or other dissolving agent should be avoided if the metal being deposited comes before or near hydrogen in the electromotive series.

6. As high currents or voltages as possible should be used without causing bad deposits or low cathode efficiencies.

7. If the cathode efficiency is low increase the metal concentration of the bath should be increased.

8. Stirring the solution or moving the objects being plated should increase the efficiencies with the less active metals.

9. Stirring should not be with air if there is any tendency for the anodes to dissolve more than is needed.

10. A high temperature should be maintained in the copper cyanide bath.

11. Anode reactions are of more importance in the control of the baths than is generally realized. More thought should be given to the anodes.

PROGRESS REPORT

Researches on Electrodeposition at the Bureau of Standards

Presented by W. Blum
At Detroit Annual Meeting, A. E. S.

At present the staff of the section on electrodeposition includes in addition to the section chief and stenographer, three chemists and two aides employed by the Bureau, two Research Associates of the American Electroplaters' Society and one Research Associate of the International Association of Electrotypers. The total annual budget of the section, including salaries, traveling expenses and special equipment, is about $30,000. Of this amount, about $20,000 is appropriated by the Government, $7,000 by the Research Fund of the American Electroplaters' Society, and $3,000 by the International Association of Electrotypers.

During the year, the interest in plating and especially chromium plating, has continued to increase. About 1800 requests for information have been answered by letter. In addition about 3,000 copies of Technologic Paper 346 on chromium plating have been sold by the Superintendent of Documents, making about 6500 copies of Technologic Paper 346 on chromium plating have been copies of the paper on Health Hazards in Chromium Plating have also been distributed. During the year about 120 persons visited the section to discuss plating problems.

Many more requests were received for talks on chromium plat-

ing than it was possible to accept. In all about 20 addresses were given to local sections of the American Electroplaters' Society, the American Chemical Society, the American Society of Mechanical Engineers, and the American Society for Steel Treating. Through these contacts the interest in the research on plating was increased. On these trips numerous plating plants were visited.

The investigation made during the year may be summarized as follows:

I—Chromium Plating

The following phases of chromium deposition have been investigated during the year.

(a) *Health Hazards.*—In co-operation with the Public Health Service, a brief study was made of the injurious effects of chromic acid spray upon the operators, and of the methods of eliminating such hazards. It was found that continued exposure to very low concentrations of chromic acid in the air caused injury to the nasal tissues. To reduce the chromic acid to a harmless concentration, cross-ventilation should be used, with an air velocity in the duct entrance of 1500 to 2000 feet per minute. The formation of chrome sores or ulcers on the hands can be avoided by the use of rubber gloves, or by occasional applications of vaseline. If such sores form, a reducing agent such as "hypo" or the sulphide solutions used for coloring metal, also should be applied.

Details of this investigation were published in Reprint No. 1245 of Public Health Reports by J. J. Bloomfield and W. Blum. A copy of this paper may be obtained on request addressed to the Bureau of Standards.

(b) *Mechanical Applications.*—A survey of the applications of chromium to gages, dies, and tools in over 100 plants was made and published by W. Blum in *Mechanical Engineering,* for December, 1928.

(c) *Specifications.*—A Federal specification for chromium plated brass plumbing fixtures has been adopted, which provides that the brass shall be plated either with (1) 0.002 inch of chromium, or (2) 0.0002 inch of nickel and 0.00002 inch of chromium. Installations furnished on this specification will be inspected at intervals in order to determine whether one or both types of plating on brass are satisfactory.

(d) *Conductivity.*—A research in progress by H. R. Moore

has shown that solutions of pure chromic acid have a maximum conductivity when the concentration is about 5 *M*, i. e., about 500 g/L or 67 oz/gal of CrO_3. This research is being continued to determine the effect of trivalent chromium on the conductivity and other properties of chromic acid solutions.

(e) *Throwing Power.*—A study by H. L. Farber, Research Associate of the Electroplaters' Society, to be reported later in this meeting, and published in the near future, has shown that while no radical improvements in throwing power are probable with the present type of chromic acid baths, it is possible by the proper selection of composition, temperature and current density, to obtain an appreciable improvement in throwing power above that usually secured. In any case the throwing power is so poor that, in order to satisfactorily plate irregularly shaped articles, the anodes and cathodes should be so placed as to produce as nearly a uniform current density as possible.

(f) *Protective Value of Chromium Plating.*—At the Research Conference held in Newark on April 6th, it was pointed out that one of the greatest needs in electroplating today is the definition and specification of plated coatings which will furnish the required protection against corrosion under various conditions of exposure. This need is especially important in connection with the extensive use of chromium plating on automobiles and other equipment. The Research Committee therefore adopted as the subject for study by its Research Associates "The protective value of plated coatings with special reference to chromium coatings."

A tentative outline for this research has been prepared, which will be submitted for discussion in the latter part of this session. Prior to entering upon this systematic investigation, W. P. Barrows, Research Associate of the Electroplaters' Society, has been engaged in a preliminary study of methods of testing the porosity of chromium deposits upon various metals, such as steel, copper, nickel and brass. Abundant evidence has been obtained that, as previously reported, chromium deposits are porous, and frequently contain hair line cracks. Further work will be required to determine the relation of such porosity to (a) the thickness, (b) the conditions of deposition, and (c) the behavior in both accelerated and normal exposure tests.

(g) *pH of Chromium Plating Solutions.*—Previous observations have shown that it is difficult to measure the pH of strong

chromic acid solutions by the customary colorimetric or electrometric methods. A recently developed electrometric method, based on the "glass electrode" is apparently not affected by strong oxidizing agents. M. R. Thompson is now engaged in a study of this method to determine whether it is applicable to chromic acid baths. Subsequently it may also be applied to cyanide solutions. Some time will elapse before definite data are obtained. The method is intricate, and if applicable will probably be useful only for research.

(h) *Physical Properties of Chromium.*—The section has continued its cooperation with other divisions of the Bureau in the study of physical properties. Gages and other articles have been plated for use in studies by the Metallurgy Division on the wear of metals.

The reflecting power of chromium has been determined, and included in Bureau of Standards Research Paper 39 by W. W. Coblentz and R. Stair (which may be obtained by sending 5 cents, not stamps, to the Superintendent of Documents). The results show that in the visible spectrum, chromium has a reflectivity of about 70 per cent as compared with about 60 per cent for nickel and 90 per cent for silver. In the ultra violet region, chromium is a much better reflector than either nickel or silver.

Experiments are in progress upon the density and thermal expansivity of chromium, using chromium tubes produced by depositing a thick coating of chromium upon a polished brass tube which is then dissolved out with nitric acid. Final data have not yet been obtained.

II—Spotting Out

The research by W. P. Barrows on spotting out has been completed and the results published as Bureau of Standards Research Paper 72. Copies of this paper have been purchased by the Research Committee and distributed to all members and to subscribers to the Research Fund. Additional copies may be obtained by sending 10 cents (not stamps) to the Superintendent of Documents, Washington, D. C.

III—Cyanide Plating Solutions

Further experiments by M. R. Thompson have confirmed the high purity of sodium and potassium cyanide prepared by him for research purposes. The Liebig titration with silver nitrate is accurate. When potassium iodine is added to make the end-point

more sensitive, the results are not appreciably affected by constituents likely to be present in commercial cyanides or in silver plating solutions. The method is therefore reliable for determining the free cyanide in silver plating solutions.

(b) *Silver Plating Baths.*—It is our intention to study systematically the composition and operation of each of the important cyanide plating solutions. Silver baths have been selected for the first study because such baths are comparatively simple in composition, and can be readily analyzed. This investigation has just been started by R. M. Wick, the successor to N. Bekkedahl. The experience gained with silver will be valuable in the study of other more complex cyanide solutions such as of copper, zinc and brass.

IV—Nickel Plating Solutions

During the year the various methods of measuring pH in nickel plating solutions were studied in co-operation with five industrial and educational laboratories. The results obtained will be presented later in this session, and will be published in the near future.

V—Addition Agents in Copper Electrotyping Solutions

R. O. Hull, Research Associate of the International Association of Electrotypers, investigated the use of various addition agents in acid copper baths. Phenol (carbolic acid) was found most promising and after extended laboratory tests it has been installed for trial in several commercial electrotyping plants. Observations and analyses are being made on these solutions to determine the effects of the phenol, and the rate of depletion. The solution used in these plant tests contains 250 g/L (33 oz/gal) of copper sulfate, 75 g/L (10 oz/gal) of sulfuric acid and 1 g/L (0.13 oz/gal) of phenol. The latter is first heated to 100° C. (212° F.) with concentrated sulphuric acid to form phenol-sulfonic acid, which after cooling, is added to the bath. At 40° C. (104° F.) with good air agitation, current densities up to 30 amp/dm^2 (280 amp/sq. ft.) may be used. The deposits are smoother and harder than those from solutions with no addition agent. These experiments will be completed by N. Bekkedahl, successor to R. O. Hull, who recently resigned as Research Associate of the Electrotypers' Association.

VI—Iron Deposits

In cooperation with the Bureau of Standards, T. P. Thomas of the Bureau of Engraving and Printing, has produced thick iron plates from a solution containing about 300 g/L (40 oz/gal) of

ferrous chloride and 335 g/L (45 oz/gal) of calcium chloride. The solution is kept about 0.01 to 0.02 N in free hydrochloric acid. A temperature of 90° C (196° F) and a current density of about 7 amp/dm² (65 amp/sq. ft.) are used. The cathodes are moved mechanically, and the anodes, of pure Armco iron, are enclosed in alundum pots to prevent anode sludge from reaching the cathodes and causing roughness. The iron is quite strong and ductile. The detailed results will be published as soon as more experience is obtained regarding operation on a commercial scale.

VII—Future Plans

The Bureau has received during the year active and cordial co-operation from the officers and the Research Committee of the Electroplaters' Society. The Research Conference in Newark on April 6th was well attended, and the discussions were valuable and helpful to us. This experience indicates the desirability of holding future conferences in different localities, so as to stimulate interest in the research work.

During the next year, we hope to complete or make good progress upon the unfinished investigations referred to above. In these and all of our activities, we will be glad to receive suggestions and criticisms, in order that we may render the results as valuable as possible to the electroplating industry, and to the many industries in which electroplating is involved.

"ELECTRODEPOSITION OF IRON"

T. P. Thomas

From the first recorded deposition of iron in 1846 to the present day, the electrolysis of iron solutions has been the subject of many investigations. The object for which the electro-deposit is required must be considered when selecting the type of bath to employ. One that would do well for steel-facing might be quite unsuitable for refining.

A careful consideration of the numerous solutions proposed brings about the following classification: (1) Those based on the use of sulphate of iron; (2) those based on the chloride, and (3) those containing both sulphate and chloride.

The chloride bath has advantages over the sulphate solution in the following respects: (1) It can be made more concentrated

and hence will contain more metal; (2) it is a better conductor of the current; hence lower voltage is required; and (3) in general the rate at which the chloride bath can be worked is greater than in the case of the sulphate solution.

The sulphate bath is preferable in the following respects: (1) It can, if necessary, be worked cold (25° C.) whereas the chloride baths require a much higher temperature; (2) the oxidation of the solution is less, and (3) the deposits oxidize very much less quickly than do the deposits from the chloride baths.

The great objection to mixed electrolytes is the difficulty of control, especially on the anode side of the bath.

During the late war, the British army repair shops were confronted with the problem of repair or replacement of enormous numbers of worn parts of automotive machinery, and decided to attempt the salvage of many of the simpler parts by the electrodeposition of iron.* The method described was that using a cold ferrous ammonium sulphate bath at low current density. Since it was used successfully in commercial work for the production of about 6000 repaired parts, experiments along the same line were started at the Westinghouse Research Laboratory. The apparatus used was essentially that described in the article mentioned except that the current used for cleaning was obtained from a 0.75 Kw., 60 Volt generator, direct connected to an induction motor; while the plating current was taken from storage batteries at any desired voltage. The anodes of 0.036 in. Armco iron made into cylinders, were hung on a wooden rocker frame driven by a wooden connecting rod directly connected to a small reducing gear. The solution used in the British Work, 75 gm. of ferrous ammonium sulphate per liter, was tried, using the current density recommended; namely 0.33 amperes per sq. dm. Under these conditions the deposit on a cold-rolled steel sample was smooth, bright, and adherent; it withstood bending and refused to chip off even when attacked at the junction of coating and parent metal with a cold chisel. A current efficiency of about 75 per cent was obtained, the rate of deposit being about 0.0002 in. per hour.

Baths thus prepared had an H ion concentration of 10^{-5} (pH=5). They were rather uncertain in their behavior, being especially likely to oxidize when used with small pieces. Adding ferrous-

*B. H. Thomas, Automotive Industries, Aug. 26, 1920.

carbonate "mud" reduced this tendency to oxidize, and the baths which were worked steadily maintained a pH of 6. Powdered charcoal helped to secure a good deposit, and was used in all subsequent work. Various addition agents, such as boric acid, tartaric acid, ammonium tartrate, etc., were tried in an effort to obtain a consistently smooth adherent deposit, but gave unsatisfactory results. During this period of the work, it was found that additions of ferric iron resulted in either a hard brittle coating, similar to that sometimes obtained when the acidity was too high, or no coating at all, and that satisfactory deposition did not take place until all the ferric iron had been reduced to the ferrous state.

This preliminary work established a definite set of rules of procedure by which we could be certain of a good deposit. After most of the grease had been removed from the piece to be plated, and the portions on which no deposit was desired had been covered with a mixture of 90 per cent hydroline (M. P. 100° C.) and ten per cent paraffine, it was made the cathode for three minutes in a ten per cent solution of commercial lye and salsoda in equal proportions. A current density of three to five amperes per sq. in. was used in this portion of the cleaning. The piece was then washed in running water and made the anode for an equal time in thirty per cent commercial sulphuric acid, using about the same current density. In the acid cleaning bath, it is important to have the current density sufficiently high so that the iron becomes passive and gases freely. If too low current density is used, the piece is attacked by the acid and cleaning does not take place. With sufficient current to produce passivity, as indicated by free gassing of the work, the piece comes from the acid cleaning bath with a beautiful pearly lustre, and upon washing in running water and transferring to the plating bath without touching in any way the cleaned portion or allowing it to dry, a satisfactory coating is obtained. While the work is in the acid cleaning bath, any motion of the work will sometimes result in a decrease in current and cessation of gassing of the work, showing that it has become active, i. e., is being attacked by the acid. When this tendency is very pronounced, it is an indication that the current density is too low. After cleaning in this manner and transferring immediately to the plating bath we found it possible to produce satisfactory coatings at the rate of 0.0006 in. per hour, correspond-

ing to a current density of one amp. per sq. dm., which is three times the rate attained in the British work.

The dilute plating bath used at room temperature and with low current density produced a coating that was satisfactory for most purposes, but was rather difficult to machine. The most serious drawbacks to this method were the slow rate of deposit and the tendency to produce pitted deposits, which always resulted if the anode area was not sufficiently large in proportion to the cathode area and the exposed surface of the solution.

The next line of attack was in the field of hot concentrated baths operated at high current densities. A paper by Mr. W. A. Macfayden* gave complete data on the use of a bath with 300 gm. of ferrous ammonium sulphate per liter, worked at 50 to 75 degrees C. All of Macfayden's work was done with still solutions, but as our work with cold baths had indicated the value of ferrous-carbonate mud and charcoal, which necessitated stirring, we combined the two methods. The deposits obtained, using a current density of seven amperes per sq. dm., were softer than those from the cold baths, perfectly adherent, and of a velvety appearance. This method gave a greater increase in the rate of deposit, as the current efficiency increased to practically 100 per cent. In the hot concentrated bath, anode corrosion is so complete that oxidation is negligible. The addition of ferrous carbonate mud is practiced, but the amount used is very small. These baths may be left for weeks, when not in use, without any serious oxidation. They have been used continuously during the daytime for weeks without deteriorating. Another advantage of the hot bath is that so high a rate of deposit (0.004 to 0.005 in. per hr.) may be used that practically any salvage job can be done in one working day.

In order to test fully the working qualities of deposits produced by these methods, we have built up worn or undersized parts of many kinds, which have then been put in service. These run all the way from the badly scored bearing of a 1/20 h. p. motor shaft to an experimental aeroplane propellor hub, including both the bearing and pinion fit on a street railway motor shaft. Plug and thread gages have been repaired and have given good satisfaction, although they are not as hard as heat-treated tool steel. It is,

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*Trans. Faraday Society, 1920, Vol. XV, 98.

of course, possible to carburize such pieces, when they will compare favorably with the original gages. One of our prize exhibits is the shaft from a three h. p. motor which was used on a six spindle drill press with a rather short, very tight belt. This shaft was ground undersize to simulate wear, then plated with the hot bath method, ground and reassembled. It ran steadily on the day shift for eight months and was then taken out for inspection. No wear could be detected, either by micrometer or appearance. As this shaft had had about a thousand hours of actual service it is quite evident that this material is all that can be desired for bearing service. The press fit tests, severe bending, and forging pieces with coatings 1/16 in. or more thick, all indicate that platings produced in this manner are perfectly anchored to the parent metal.

(Applause.)

CHAIRMAN SMITH: Are there any questions?

QUESTION: I would like to ask if there is any trouble with the anode corroding.

MR. THOMAS: No trouble at all. We had complete anode corrosion, so that the composition of our bath or solution remained practically constant. No additions of iron salts was necessary to the bath.

MR. SNYDER: I would like to ask Mr. Thomas in the use of this iron in the hot solution if there was a formation of a black sludge on the iron and if there was a tendency of this sludge to become suspended in solution and thereby cause a roughness in the deposit in any way.

MR. THOMAS: That is in the hot bath?

MR. SNYDER: Yes.

MR. THOMAS: I can't say that there was. Possibly in the cold we did have some covering of probably a scum at the anode, but neither in the cold nor the warm did we find the presence of that. But in both of them we found the presence of the powdered charcoal seems to take us away from any difficulty of that kind.

MR. W. M. PHILLIPS: Does the deposit contain any carbon?

MR. THOMAS: I will admit that we did not so far analyze our deposits. Although we have taken microscopic pictures or slides of the deposits, cross-sections, and have not noticed the presence of carbon.

(Continued on page 35)

A. E. S. PAGE

Assembled Expert Scraps With and Without Significance

A man sent in one dollar to a concern which guaranteed to show him how to save half his gas bills. Here's the answer he got: "Stick them in a scrapbook."

Magnolia: "When Mandy went and got married, us girls give her a shower."

Pansy: "Dat sho' was nice. Ah'll bet her husban' wuz glad to get 'er all nice and clean."

"What is your brother in college?"

"A halfback."

"I mean in studies."

"Oh. In studies he's away back."

Are You Happy?

An English Bishop has attempted to outline the qualifications necessary in order that a man, or woman, may be really happy. Among other things he says:

"No quarrelsome man is happy.

"A happy man thinks of others, tries to help where he can, not only in the 'big' things of life, but in small ordinary routine matters.

"He must be keen without pushing, for 'push' too often leads to disappointments.

"He must be sincere. He must have a sense of humor, and not overfearful of what other people may say or think about him.

"He does not expect too much from people, but he is always on the look-out for the best in others, and slow to impute mean motives.

"He is neither intolerant or impatient with people who disagree with him. He finds refreshment in beauty, and enjoys friendship, but cares little for mere conventions. Some friends he finds in books and pictures.

"He dislikes shams, and is sensitive to truth. He is never a Pharasee, and, if religious, he will make his religion attractive to others without expecting or desiring them to 'toe the line' to his own religious convictions."

One of the chief sources of happiness lies in making others happy.

DR. A. K. GRAHAM: In using the carbon, I should think the form in which it was added would have an effect on the results obtained. For instance, much finely suspended matter in the solution might seriously interfere with the deposit. On the other hand, if the carbon were activated, it might have a decided value in cutting down any polarization, and as I understand it, in iron deposition there is a tendency for the hydrogen deposited at the cathode to cause trouble, and as far as the anode is concerned, I believe that the black scum which might form there would be associated with oxidation. If the gas evolution of both electrodes is reduced by the addition of carbon, it evidently acts as a depolarizer, and this action would undoubtedly depend upon the form in which the carbon was added.

I would like to know what form of carbon was used and just how you got it.

MR. THOMAS: We added powdered wood charcoal, of a fineness that would go through about a No. 10 mesh—not far from that, that is just a guess. We just powdered it up in the most convenient receptacle we had at hand. We really didn't pass it through a mesh, through a sieve, but it was as fine as you could powder it with mortar and pestle. That was the grade of charcoal we added, ordinary wood charcoal. The presence of that charcoal in the bath certainly aided in our work very much.

MR. HOGABOOM: May I ask what percentage of the oxide of iron that may be in the solution that floats over through decomposition would you attribute to the formation due to the attack of the carbon dioxide and monoxide of the air on the solution, and then the evolution of gases, and does not that probably form a blanket to prevent that?

MR. THOMAS: Possibly, when the bath is standing idle. I hadn't had that idea brought to me before; but during the operation of the bath, I question whether you would run into any difficulty of that nature.

MR. WEINMAN: Does any variation in the difficult types of original metallic composition of your tools make any difference in your deposition of metal? You take an alloy steel, for instance, and a plain ordinary carbon steel.

MR. THOMAS: No difference as far as results obtained. That is, we were able to obtain a satisfactory plate on cast iron, just as satisfactory as on, say, cold rolled steel, or possibly alloy steel.

Announcements

BALTIMORE-WASHINGTON BRANCH

Annual Meeting and Banquet will be held January 25, 1930, at the Hotel Raleigh, Washington, D. C.

Lest we forget—1930 Annual Convention will be held June 30-July 1-2-3 at Mayflower Hotel, Washington, D. C.
Baltimore-Washington Branch.

CHICAGO BRANCH

Extends to all A. E. S. members and friends an invitation to attend the Annual Meeting and Banquet, Saturday, January 18, 1930, at the famous Palmer House, Chicago, Ill.

Educational Meeting at 1:30 P. M. and Dinner Dance at 7 P. M. Tickets $4.00.

J. Kretchmer, Secretary, 1914 Warner Avenue, Chicago, Ill.

ST. LOUIS BRANCH

Extends you a hearty welcome to their Annual Banquet and Educational Meeting January 25, 1930, at Chase Hotel, St. Louis, Mo. Write or call E. J. Musick for further information.

THE MEASUREMENT OF CHLORIDES IN NICKEL PLATING SOLUTIONS

Donald Wood

The title of my paper is "The Measurement of Chlorides in Nickel Plating Solutions," but you will find I will say very little on that subject. I had naturally intended to, in connection with presenting a chloride measuring instrument, but I don't want to make the thing commercial, and I find that I have something to say which I think is more important.

You perhaps have seen the instrument which is on the table at the front end of the room. To that extent, my talk is commercial, and that is the last I will say of it.

Practically every speaker at this convention has said something on control, but each one has mentioned control as a control of some particular factor. There has been practically nothing said of control as a whole. It seems to be the aim of every foreman plater to produce a uniform product over any given period of time. In order to have perfect uniformity in a product, it means that not only most of the factors have got to be controlled, but that all the factors have got to be controlled to the extent to which you wish to control a product.

Much has been said by Professor Turnock of the electrical control. There have been at other meetings talks of pH, nickel-iron control, temperature control, and any number of other single factors. Let us take an analogy of a man who wants to weigh an object, or say a given amount of some chemical. He uses a balance, and after he has balanced his material, finds he has used six weights, and to his surprise he finds that a couple of the weights have lost their markings. Just for example: As long as he can keep those weights, he can measure the same amount of material again; but should he lose those two unmarked weights, he has absolutely no way of finding what his original weight was, and he can not replace the amount of material he originally weighed.

This same analogy represents itself in nickel plating, where a man has a tank which is producing work up to the standard he is requiring. He controls, say, his acidity, his nickel-iron concentration, temperature and electrical and time factors. As long as those factors remain constant, or as long as he controls those, he

feels that he is getting a uniform product. But shortly, with all those factors measuring the same, he finds that there has been a difference. This is perfectly probable, because there are a great many other factors involved in the ordinary solution besides those which he has measured. Chloride is one of them, but I don't bring it up for the purpose of emphasizing it. The ammonium item, which is generally used, is never measured as far as I know in commercial practice. That probably will be measured at some future time. Measurement of chlorides has only recently come sufficiently before the platers so that they are interested in it. I don't want to say anything about why chlorides are necessary, because I think Mr. Hogaboom's article in the April Metal Industry covered the subject completely, and anything I might say would only repeat what he said.

The only point that I am trying to make is that where you have a variable factor in your solution which you are not controlling, you can't hope to control your result. I think the time will come when all solutions will be even less complex than they are today. In my own short time, I have seen a change from solutions which might have contained a dozen items to solutions containing only five or six or seven items.

The question of polarization of nickel anodes is a slight infringement on Mr. Hogaboom's article, but to make my point more clear, how can you control your electrical factors unless you control polarization effect? Your voltmeter measures voltage drop across your tank from the outside bars, that is, you measure not only your solution conductivity and the other factors of resistance between the point where your measurement is made and the point where it completes the circuit, but you are measuring at the same time polarization of the anode. No man can hope to assume uniform conditions of voltage and amperage unless he assumes uniform conductivity through the solution. If, for instance, in the old system where only a voltmeter was used, a man always were to plate at 2 volts, and one day the anodes coated over, he is not getting the same ampere flow.

Very little attention seems to be paid to the question of maximum current densities possible. That also is very closely connected with the question of polarization, and I would like to mention it. If a nickel anode is perfectly clean, no particles can detach themselves from it, and no sludges form in the solution; as might be

comparable to a newly made solution it will be found that a certain maximum current density is possible before any nodules form on the work. If, after that solution has been in operation a few weeks, you were to check the maximum current density again, you would find that it would be considerably lower, that is, that at the original current density the work would be rough. This is very closely related to floating sludge, and it seems very probable that that is a factor which is worthy of control. The time that you have to plate is inversely proportional to your maximum current density, and I guess time is money, even when it is compared with the cost of current.

Once more, in closing, I want to say I think very little has been thought on the subject of universality of control rather than accuracy of control. Accuracy must be present, but I believe that we are devoting too much attention to the question of tenths of percents and not enough time to the question of how many factors are we leaving out entirely.

(Applause.)

CHAIRMAN FEELEY: Gentlemen, you have heard Mr. Wood's talk on control for chlorides in nickel solutions. Is there any question you would like to put before proceeding to the next paper?

MR. OSCAR SERVIS: I would like to ask, Mr. Wood, what was your basis of determination? In other words, what chloride did you determine as your basis? Ammonium chloride or sodium chloride, or what?

MR. WOOD: I would like to answer this gentleman's question by saying that all chlorides are measured, no matter what form they were put in. It is not a chemical that is measured, it is an ion. In every case, your ordinary measurements are measurements of ions, and not chemicals as they are put in. For instance, your pH comparator measures hydrogen ions; your nickel comparator measures nickel ions. The chloride set, which is not a comparator, measures the chloride ion. Or maybe I can give you an idea what I mean by this. (I am afraid to some gentlemen my explanation may seem a little bit juvenile, but I would like to make it in my own way.) Whenever you dissolve any chemical in a solution, the first thing that happens is that it dissolves. You no longer have the characteristics of you chemical. Any of the chlorides that you are using in common with practi-

cally all inorganic chemicals after they dissolve, break up to some extent into ions. Your nickel chloride, for instance, breaks up into nickel ions and chloride ions.

These ions (you will have to use your imagination a little bit) are particles having no relation to the element which they represent. They may be particles and may not be. I don't know but that is a questionable subject. But they do, and this is pretty definitely known, bear charges. Any chemical which is a commercial product, has the charges within it balanced against one another so that it represents a zero potential, if you would like to call it that, but when it breaks up or dissociates in solution, forming ions, one-half of it carries with it the positive charges and one-half carries with it the negative charges. In the nickel chloride, for instance, the nickel ion is positively charged and the chloride ion is negatively charged. Now if I take nickel chloride in water, and add ammonium chloride, I still have only three ions in the solution; I haven't four. If I measure the chloride ions, I have measured the element which we are interested in, the chloride element, and whether the balance was put in as nickel or as ammonium ions is unimportant from this point of view.

Does that answer your question?

MR. SERVIS: That is determined, then, as total chlorides?

MR. WOOD: Yes, total chlorides.

PITTSBURGH BRANCH

Our regular meeting held Friday evening, December 6th, was not very well attended. Secretary reported the serious illness of Mr. Edwin S. Gray, who has been ill since last April with cyanide poisoning. The doctors have done everything, but the trouble seems to keep him confined to his bed. He would be very grateful to hear from any one that has had any experience with this trouble as to how to overcome it. All those present expressed their sympathy and best wishes for his speedy recovery.

Owing to the lack of interest in our monthly meetings, and after a long discussion, it was decided to hold our meeting every other month and see what the result would be, and at that time the branch would have some outstanding person address the meeting upon a subject that would be of interest to every plater. Our next meeting will be held on the first Friday evening in February, 1930, in Room E, Keystone Club, and at this time we trust that we can have more interest shown and get back to business.

S. E. HEDDEN, Secretary-Treasurer.

BOSTON BRANCH

The regular monthly meeting of the Boston Branch of the American Electroplaters Society was held at the American House, Boston, on Thursday, December 15th, at 8 p. m.

The meeting was called to order by President L. A. Gale. All officers were present. Communications and bills were read and approved. Under the head of new business the governing committee brought in a report approving Mr. Wood's offer to have all interested members attend a weekly educational meeting at his laboratory. President Gale instructed the secretary to write all members informing them of the opportunity.

Mr. Wood, as librarian, took charge of the educational part of the meeting. He read a technical discussion on hydrogen ion control and afterwards demonstrated the pH comparator, using two solutions with a distinct difference in the acidity. The colormetric method of nickel determination was also demonstrated and an entirely new compact outfit for chemical determination of the chlorides in a nickel solution, accurate to one-third of an ounce per gallon and requiring no more than two or three minutes for the test.

From this point on a very general discussion was entered into by all present. Several very new and interesting problems were brought up and everyone became so engrossed that the meeting had to be forcibly adjourned at 10:45 p. m.

Respectfully submitted,
THOS. JOHNSON, Secretary.

NEWARK BRANCH

The Newark Branch held its regular monthly open meeting with its moving pictures which the committee has been able to obtain, the title of which was "Story of Bakelite." These films were very interesting throughout and they have a great educational value. There is much discussion over the films. A fine attendance was on hand—about 52 members were present.

Yours very truly,
GEORGE REUTER, Secretary.

LOS ANGELES BRANCH

The meeting was held as usual on the second Wednesday in November at the Y. M. C. A. Hall, President C. E. Thornton presiding and all officers present. Thirty-seven sat down to dinner at 6:30 p. m.

The business session was exceptionally long, and very little time was spent on the educational discussions.

L. Riess of Philadelphia Branch, Robert Gripp, our first president, and Mr. Blum of San Francisco were present, all three giving us an interesting talk. Mr. Blum told us of a fellow who used "red pepper" to make a brass solution work good, this being voted a "hot one."

A motion was made, seconded and carried that the Los Angeles Branch donate $50.00 this year to the Research Committee.

The question box contained the following:

1. Question: How can Verde or Green be plated on an article?

Answer:

Bichromate of Potash	12 oz.
Sulphate of Copper	4 oz.
Water	1 gal.

Use copper annodes.

2. Question: How to test an acid copper solution for acid and metallic content?

Answer: Make up a new solution as a standard solution, add slowly known amounts of carbonate of copper till saturation point has been reached, and keep record of amount used. Take 4 fluid oz. of solution to be tested, add carbonate of copper. Should this solution take up more than standard solution, metal is needed; if less, acid is needed.

3. Question: I chromium plated two bumpers on one rack, first copper, then nickel, then chromium; one of the bars rusted, the other is perfect; what caused the one to rust?

Unanswered.

Platers please help. Chas. Russell promised to get in touch with members of the Board of Education to know if arrangements could be made for a Chemistry Class.

The meeting adjourned at 10:30 p. m.

We urge all of the members and applicants to be present at the next meeting, which shall be held in the Y. M. C. A. Hall on December 11th, at 6:30 p. m.

M. D. RYNKOFS, Secretary-Treasurer,
Los Angeles Branch of A. E. S.

CHICAGO BRANCH

The regular monthly meeting of Chicago Branch, A. E. S., held Saturday, December 14, 1929, at the Atlantic Hotel.

Meeting was called to order with Pres. S. J. C. Trapp presiding and all officers present.

If you want to meet all your friends come to the annual banquet of Chicago Branch, A. E. S.

The banquet committee reports everything in readiness and a good time is assured all who attend.

Do not forget the date—Saturday, January 18, 1930.

The place—Palmer House at Chicago, Ill.

As the paper that our instructor, Mr. H. Faint, was to talk on, was rather long and the hour was getting late, it was decided to turn the meeting over to Mr. Paul Kiel of the Aluminum Company of America, who gave a talk on "Aluminum Buss Bars," which was very interesting.

The librarian then took charge and the following questions were found in the box:

Ques. No. 1—Is the hydrometer test for chrome solution reliable for metal content?

Ans. No. 1—Always test at 70 degrees F. and it will be reliable.

Ques. No. 2—Will steel polished to a mirror finish, chrome plated direct 40 to 60 minutes, then chrome buffed, be practical?

Ans. No. 2—Depends on whether the article is to be used outside where the elements can act on it or inside where it will be protected.

Ques. No. 3—What causes chrome to miss in small spots? Spots resemble a cluster of water spots.

Ans. No. 3—Low current was given as one reason, poor contact as another, also solution being too cold.

Ques. No. 4—Give formula, if possible, for plating a red deposit (not copper) to look like Chinese cinnabar on brass.

Ans. No. 4—Give parts a light coat of silver, then hang in a solution of sodium chromate 20 grams per liter and use reversed current.

Ques. No. 5—In order to prevent nickel pitting what is the customary quantity of sal ammoniac added? When nickel chloride is added, how much? When sodium perborate is added, how much?

Ans. No. 5—Ammonium chloride and nickel chloride are not added to prevent pitting, but to add conductance to a nickel solution. One-eighth oz. of sodium perborate per gallon is usually enough to stop pitting.

Ques. No. 6—What does sodium fluoride do in a cyanide zinc solution?

Ans. No. 6—This question was unanswered. Platers please help.

Ques. No. 7—Give formula for copper plating wax.

Ans. No. 7—Copper sulphate solution should have a density of about 25 to 30 degrees B. Sulphuric acid should be low, about 1 per cent. Current density, ½ to ¾ volt.

Ques. No. 8—The addition of potassium permanganate was recommended to prevent nickel solution from pitting. How much is added?

Ans. No. 8—Add about 1 oz. of a normal solution (31.6 grams per liter) per 100 gallons of nickel solution.

October Question Box

Ques. No. 1—Pieces of steel and die cast metal are plated in the same brass solution at the same time. Why does more brass deposit faster on the cast metal than on steel?

Ans. No. 1—The die cast metal is a better conductor and also plates by immersion.

Ques. No. 2—If a nickel solution is too acid, the solution is high in metal and don't want to use ammonia, what else can I use?

Ans. No. 2—Nickel carbonate.

Ques. No. 3—Can chromium be plated direct in aluminum, if so, is a hot or cold solution used?

Ans. No. 3—Yes, it is being done. Polish in the regular way, give a quick bright dip, rinse and then chrome plate in a hot solution.

Ques. No. 4—Will copper sheet rolled anodes cause a dark deposit

of copper? These anodes are 6 inches wide and are 5 inches apart. I never had this deposit with cast anodes.

Ans. No. 4—Try an addition of cyanides. If sufficient cyanide is present, then it may be due to impurities in anodes.

Ques. No. 5—Are aluminum buss bars an advantage to use?

Ans. No. 5—No. They do not have the same ampere carrying capacity per square inch.

Ques. No. 6—Is it necessary to use hot cleaners on any class of work?

Ans. No. 6—Yes. It may be possible to use cold cleaners but not practical.

Ques. No. 7—Is it necessary to wash 14 inch disc knives in gas before cleaning, for nickel plating? These knives are highly polished.

Ans. No. 7—It was thought kerosene or some other solvent that would not evaporate too fast, would be better than gasoline.

Ques. No. 8—Has cyanide solution any corrosive action on iron tanks, also has caustic soda the same action, if any?

Ans. No. 8—There is some corrosive action, especially if iron is high in carbon content, also if chlorides are present. Ordinarily the action is very slow.

Ques. No. 9—Would the process of converting sulphuric acid to muriatic acid be a saving?

Ans. No. 9—No.

Ques. No. 10—What is the best method for nickel plating aluminum?

Ans. No. 10—Read Harold K. Work's article in the January, 1929, Review.

J. C. KRETSCHMER, Secretary.

HARTFORD-CONNECTICUT VALLEY BRANCH

The Hartford-Connecticut Valley Branch, A. E. S., held its regular monthly meeting at the Hartford Chamber of Commerce, 805 Main Street, Hartford, Conn., Monday evening, November 25, 1929.

The meeting was called to order at 8:30 p. m., with President Beloin in the chair. Minutes of the previous meeting were read and accepted. There were no communications. One bill was ordered paid.

Mr. E. L. Wood, chief chemist of the Landers, Frary & Clark Co., of New Britain, Conn., and one of the Research Committee, gave a very interesting talk, which included work already done by them, and also on proposed work to be done during this year. His talk was very instructive and much appreciated by the members. In conclusion he was given a rising vote of thanks.

It was voted to give delinquent members only to the end of this quarter, which ended November 30th, to make some declaration in regards to payment of dues, and at the end of the term, if no communication had been received by the secretary, they were to be suspended.

The meeting was adjourned at 10:30 p. m. There was an attendance of sixteen members and visitors.

VERNON E. GRANT, Secretary.

TORONTO BRANCH

The regular monthly meeting of Toronto Branch was held in the Canadian Foresters Hall on Monday, November 25, 1929, at 8 p. m. President J. Walker presiding.

There was a fair attendance. The Research Fund was voted a donation of $50.00 for 3 years. The report on the Practical Values of Chromium was read and discussed. As nothing but routine business was presented, the meeting was adjourned early until Monday, December 23, 1929. H. W. GRAHAM, Secretary-Treasurer.

PHILADELPHIA BRANCH

Owing to the death of our President, Willard M. Scott, who died December 3rd, a large number of members assembled on the evening of December 6th, to view and pay tribute to our deceased President. And quite a number of members attended the funeral Saturday, December 7th.

The deepest sympathy of the Branch is extended to the family.

The Philadelphia Branch extends to Newark Branch their kind appreciation for the floral tribute.

PHILIP UHL, Secretary.

CLEVELAND BRANCH

The December meeting of the Cleveland Branch did not have the enthusiasm that our November meeting had. Due, perhaps, to the fact that our key man for the evening did not put in an appearance and we were left a little flat. However, our Smoker Committee reported that Cleveland Branch is going to outdo itself in the way of entertainment and that those who do not come to our smoker will be sorry everafter.

Mr. E. S. Thompson, our member from Erie, Pa., who is seldom absent from our meetings, sent a Christmas greeting in the form of a box of cigars, which were passed around a few times and very much enjoyed by those present, and for myself, I will say they were good smokes and we appreciated them very much.

We hope to have a better attendance and more pep for our next meeting. H. J. TERDOEST, Secretary.

DETROIT BRANCH

Detroit Branch, A. E. S., held its regular monthly meeting Friday evening, December 6th, at the Statler Hotel, Pres. B. F. Lewis presiding. After the regular order of business the meeting was turned over to the chairman of the Educational Committee, Mr. Jameson, who introduced the speaker of the evening, Mr. Roscoe Rice, plating engineer of the Hayes Wheel & Forging Co., of Chatham, Ontario, who gave an interesting and educational talk on "Zinc Plating."

CHAS. M. PHILLIPS, Secretary and Treasurer.

BALTIMORE-WASHINGTON BRANCH

The above branch held its regular monthly meeting, Dec. 7, in the Enoch Pratt Library, Calhoun and Hollins St., Baltimore, Md. President M. J. Kraft presiding.

Dr. Blum explained to us the experiments of Lesson 3 at the Bureau.

Minutes and communications were read and approved, after which we spent the rest of the evening discussing our forthcoming annual banquet to be held Jan. 25, 1930, at the Hotel Raleigh, 12th and Pennsylvania Ave., Washington, D. C.

The afternoon session will commence at 3 o'clock, and dinner will be served at 7 p. m. Members and friends from other branches are cordially invited. Tickets $3.00.

GEO. F. P. TURNER.

ST. LOUIS BRANCH

Regular meeting of St. Louis Branch A. E. S. was held at the Y. M. C. A. on Friday, Dec. 13, 1929. After a turkey dinner, meeting was called to order by President Al. Reifling. After roll call of officers, minutes of previous meeting were read and approved on report of committee. Mr. E. J. Musick stated that all arrangements for banquet were made and would be held on Jan. 25, 1930, at the Chase Hotel; afternoon session to be in charge of M. H. H. Williams as chairman; the afternoon session to start at 2:30 o'clock.

Mr. J. Hay of Detroit will talk on Modern Methods of Cleaning for Chrome Plating and will be illustrated. Mr. Hay is well known for his efficiency in the art of electro plating. Our own Dr. L. Stout of Washington will also be on the program; he will have something of interest for all.

I take this opportunity to congratulate our good member, Mr. P. E. Miller of Evansville, Ind., who makes the trip of 225 miles each way to attend our meeting; he has attended four or five meetings, and on behalf of St. Louis Branch, I hope we have made it interesting, and I know that the members are proud of him and enjoy his presence at our meetings.

On behalf of St. Louis Branch, I wish all the members of the A. E. S. a happy Christmas and a bright New Year.

Question: Can you plate direct on silver with chrome, chrome plate, or die cast?

CHAS. T. McGINLEY, Secretary.

TO THE MEMBERS OF THE A. E. S.:

There has been a good response to the letter regarding the Membership Campaign. It has been very noticeable that the "younger" members were the ones that replied. The "old-timers" must be either getting real old or forgetful. That is not a good example to set. You have had years of real comfort from being a member. Remember how you used to wonder, worry and cuss about the working of a solution? The A. E. S. removed that worry—so, come along, show your appre-

ciation and pass on the good work to some other fellow. Fill up the pipe, put the thinking cap on and see if you cannot recall some plater who resigned or was dropped and that should be a member again. Phil Morningstar did and sent in the name of one of the original members of New York Branch, and then remembered that this fellow had two sons who are foreman platers.

Come along you "old-timers," smoke up and send in the name of a fellow who should be a member of the A. E. S., and rejoice over the return of one stray plater to the fold!

GEORGE B. HOGABOOM.

APPLICATIONS	Branch
M. G. Scholar, 1253 Los Palmas Ave., Hollywood, Calif.	Los Angeles
Joseph Maurer, 64 Eaton Pl., East Orange, N. J.	Newark
Aug. Zeider, P. O. Box 98, Vaux Hall, N. J.	Newark
Ed. McLaughlin, 381½ Springfield Ave., Newark, N. J.	Newark
M. E. Steinback, 75 N. 14th St., East Orange, N. J.	Newark
J. H. Miller, 925 Bard St., Elizabeth, N. J.	Newark
B. G. E. Keller, 1248 Diversey Pkwy., Chicago, Ill.	Chicago
E. W. Griese, 5019 Parker Ave., Chicago, Ill.	Chicago
H. R. Greeder, 5319 Montrose Ave., Chicago, Ill.	Chicago
Chas. P. Walter, 2325 Fifth Ave., Moline, Ill.	Chicago

ELECTIONS	Branch
Ben Kasakive, 501 Park Ave., East Orange, N. J.	Newark
Thos. Keating, 53 Ellington St., East Orange, N. J.	Newark
A. E. Johnston, 100 Chestnut St., East Orange, N. J.	Newark
Morris Penzensky, 301 Edge Ave., Jersey City, N. J.	New York
Jos. Pactus, 574 Logan St., Brooklyn, N. Y.	New York
H. Lagendyk, R. R. No. 11, Grand Rapids, Mich.	Grand Rapids
Jos. H. Hoefer, 1910 Maypole Ave., Chicago, Ill.	Chicago
Harold E. Wall, 1940 Lombard Ave., Berwyn, Ill.	Chicago
Henry H. Weber, 7729 N. Hermitage Ave., Chicago, Ill.	Chicago
Clarence M. Beckett, 329 George St., Turtle Creek, Pa.	Pittsburgh
Jas. F. Kelly, care Westinghouse Elec. Mfg. Co., East Pittsburgh, Pa.	Pittsburgh

DEATHS	Branch
Williard M. Scott, President	Philadelphia

RESIGNED	Branch
E. L. Tannert	New York
G. S. Robbins	St. Louis

SUSPENSIONS	Branch
L. V. Brown	Chicago
H. Crunitz	Chicago
M. J. Conners	Hart.-Conn. Valley
F. B. Stebbins	Hart.-Conn. Valley
A. S. White	Hart.-Conn. Valley
A. Platsky	New York
Ed. B. Davidson	New York

BALTIMORE-WASHINGTON

Meets in Enoch Pratt Library, Calhoun and Hollins Sts. Geo. F. Turner, Secretary, 5324 Maple Ave., Pimlico, Baltimore, Md.

BOSTON

Meets at American House, Boston, Mass. First Thursday each month. Secretary Thos. Johnson, 41 first St., South Boston, Mass.

BRIDGEPORT

Meets first and third Friday of each month at 62 Cannon St., Room 17, Bridgeport, Conn. Secretary, Wm. Ehrencrona, Box 301, R. F. D. No. 1. Bridgeport, Conn.

CHICAGO

Meets second Saturday of each month, at 8 p. m., Atlantic Hotel, 316 S. Clark St. Secretary, J. C. Kretschmer, 1914 Warner Ave.

CINCINNATI

Meets every Thursday, 7:30 p. m., at Vocational Training School, Spring and Liberty St. Secretary, Al. Yeager, 2021 Sherman Ave., Norwood, Ohio.

CLEVELAND

Meets first Saturday of each month at Hotel Winton. H. Terdoest, 180 Pioneer Ave., Akron, Ohio.

HARTFORD-CONN. VALLEY

Meets fourth Monday in each month alternately at 266 Pearl St., Hartford, Conn., and corner Broadway and Worthington St., Springfield. Secretary, Vernon Grant, 43 Putnam St., Bristol, Conn.

DAYTON

Meets first Saturday of each month at the Y. M. C. A., Dayton, Ohio. Secretary, Robert G. Suman, 2734 Ridge Road, Dayton, Ohio.

DETROIT

Meets the first Friday of each month at the Hotel Statler, Louis II Room, Detroit. Secretary, Chas. Phillips, 13421 Camden Ave., Detroit, Mich.

GRAND RAPIDS

Meets on the second Friday of each month at 528 Lake Michigan Drive, N. W. Secretary, Jacob Van Dyke, 1361 Union Ave., N. E., Grand Rapids, Mich.

INDIANAPOLIS

Meets the second Saturday of each month at Hotel Denison. Secretary, Louis Mertz, 1725 Union St., Indianapolis, Ind.

LOS ANGELES

Meets second Wednesday of each month at the Elite, 633 E. Flower St., Los Angeles, Calif. Secretary, M. D. Rynkofs, 1354 W. 25th St., Los Angeles, Calif.

MILWAUKEE

Meets second and fourth Thursdays of each month at Cor. 3rd St. and Highland Ave. J. N. Hock, 1229 W. 24th St., Milwaukee, Wis.

MONTREAL

Meets last Friday of month at Office of Secretary, John H. Feelay, 411 Aylmer St., Montreal, Quebec, Canada.

NEWARK

Meets first and third Fridays of each month at Franklin Hall, 41 Franklin St., Newark, N. J., at 8 p. m. Secretary-Treasurer, Geo. Rueter, P. O. Box 201, Newark, N. J.

NEW YORK

Meets every second and fourth Fridays of each month in the World Building, Park Row, New York City, N. Y. Secretary-Treasurer, J. E. Sterling, 2581 46th St., Astoria, L. I.

PHILADELPHIA

Meets first Friday of each month in the Harrison Laboratory Building, University of Pennsylvania, 34th and Spruce Sts. Secretary, P. Uhl, 2432 North 29th St., Philadelphia, Pa.

PITTSBURGH

Meets first Friday of each month at 8 p. m., at downtown branch, Y. M. C. A. Secretary, S. E. Hedden, 227 Fifth St., Aspinwall, Pa.

PROVIDENCE-ATTLEBORO

Meets first and third Thursday of each month at 44 Washington St., Prov. Engineers Rooms, Providence, R. I. Secretary, J. H. Andrews, 19 Rosedale St., Providence, R. I.

ROCHESTER

Meets every third Friday of each month at the Powers Hotel. Secretary, Chas. Griffin, 24 Garson Ave., Rochester, N. Y.

ST. LOUIS

Meets second Friday of each month at Central Y. M. C. A., 16th and Locust St. Secretary, C. T. McGinley, 8214 Fairham Ave., University City, Mo.

TOLEDO

Meets first Thursday of each month at Toledo Secor Hotel, corner Cherry and Page Sts. Secretary, W. W. Welker, 2228 Middlesex Rd., Route 2, Box 635, Toledo, Ohio.

TORONTO

Meets fourth Monday of each month at Canadian Foresters' Hall, 22 College St., Room No. 2. Secretary, H. W. Graham, 102 Robina Ave., Toronto, Canada.

WATERBURY

Meets every second and fourth Thursday of each month. Secretary, Wm. F. Guilfoile, Garden Theatre Bldg., East Main St., Waterbury, Conn.

WORCESTER

Meets Directors' Room, Chamber of Commerce, Worcester, Mass. Roger H. Bryant, Secretary, 94 Grove St., Worcester, Mass.